The Mechelecív

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IN THIS ISSUE:

- PROGRESS OF TITANIUM
- "SO YOU'RE AN ENGINEER!"
- A WOMAN STUDIES ENGINEERING
- PARTNERSHIP ENGINEERING
- MAGNETIC RECORDING

SCHOOL OF ENGINEERING
THE GEORGE WASHINGTON UNIVERSITY

APRIL 1957

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The Mecheleciv

VOL. 16 NO. 5

SCHOOL OF ENGINEERING, THE GEORGE WASHINGTON UNIVERSITY

IN THIS ISSUE

DEPARTMENTS

ON OUR COVER

Claire Chennault, a sophomore in the School of Engineering, leaves Tompkins Hall after a class.
Picture by Atwood Barwick

FRONTISPIECE

A key tube under development for the Air Force "cat eye"
Cut, courtesy of Westinghouse

(See Page 8)

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FACULTY PAGE FOR WOMEN

THE WOMAN ENGINEER

by Mrs. Bernadine L. Dunfee
Lecturer in Electrical Engineering

With the understanding that this issue of the MECHELECIV is to focus attention on women, whether as engineers or as the wives of engineers, I would, before continuing the principal theme of this article, like to salute the wife of a *student* engineer. A special tribute to her, who, of necessity, must sacrifice a great deal and do so with grace and serenity, while lending encouragement to the "lost" husband.

Further comments are directed particularly to the engineering student, and, since a woman as an engineer is not different from a man as an engineer, they should apply equally well to both. Although one dislikes being "preached at," it is wise to pause occasionally and consider such things as direction, ambition, values, etc. A person's choice of direction is often governed by his sense of values. Oftentimes a given profession is chosen because the student has visions of wealth, honor, prestige, or of "something for nothing." The glamour may blind him to the work involved, the drudgery that often comes, and the details that will plague him. An individual and, most certainly, an engineering student so directed. will find too late that he has misplaced himself.

Again, the graduate engineer in seeking employment, may have an equally distorted sense of values. In this scientific era the engineer or physicist can "write his own ticket" — the demand far exceeding the supply. It is so tempting, therefore to permit the dollar to sway one's judgement. Money is an important consideration and with our economy geared as it is, one can hardly condemn the engineer for seeking and accepting the highest salary possible. Even so, it should be emphasized that, strange as it may seem, there are other parameters, equally valuable, that should be considered. It would be well to list a few of these.

(1) The employer or supervisor, should be evaluated. He can set the tone of the working environment. Nothing can compensate for a selfish or inconsiderate "boss" who takes unto himself all the credit or who has no appreciation of the ideas and imagination of his employees.

(Please turn to page 30)

THE ENGINEER'S WIFE

by Mrs. Martin A. Mason

To the women behind our engineers:

Having been asked to write a few words to you, I am, for me, strangely as a loss for words. What can I say to you who have helped these men through their engineering training, as many of us have.

You and I know how much time and energy it has taken on both sides. We all agree, I am sure, that it was well worth the seemingly endless struggle. The end product is an individual, and what engineer is not an individual — well rounded, useful, and a much needed citizen.

Engineering requires a lot of effort. time, patience, and know-how. Our job, to stand behind these "our men," is one that we do, knowing that they are doing a much needed job in this, our modern age. Their job is not only important, it is essential to the progress of our times. In looking around us there is little we see that does not need an engineer's help — either in building or in maintenance. Everything from the food we eat and the clothes we wear to the houses we live in and the highways we drive on, needs an engineer. Ladies, let us be proud of these men and hope that we can bask, just a little, in their reflected glory.

There are also those women who have chosen engineering as their profession. To you I offer a salute in deep humility. It is a wonderful field for you to enter from both the standpoint of accomplishment and also in giving this otherwise male world a woman's point of view. My congratulations to you and much success in your work.

To each of you I extend greetings. I wish that we could all meet. Each year, I am fortunate enough to meet some of the students and their wives. It always seems sad that, for numerous reasons, it is difficult for us to get together. Maybe we should form an auxiliary. I am sure that the other faculty wives would join me in a wish to become better acquainted. Until the time of our meeting, may I wish you the greatest success in "your chosen career"—Engineer or Housewife.

THE INDUSTRIAL PROGRESS OF TITANIUM

By Barbara Jane Seehorn B. S. E. '57

I. Introduction

Eight years ago the title of such an article as this might have been: *A Look at the New Wonder Metal, Titanium.* Titanium was first commercially produced in 1948, and at that time a necessity for a "wonder" metal was felt essential to the progress of our country. The properties of titanium seemed to lend themselves well to the needs at that time; however, production was not without problems.

So many problems were presented in the commercial production that by 1954 this same article might have been entitled: *Is Titanium Actually a Governmental Gamble?* The government had sponsored the metal since it was first produced in '48, and though six years had passed, production was still quite costly; and, worse than that, consumption was seriously lagging behind production.

Today, we look at titanium in a new light — not as a wonder metal to replace all other metals or as a "governmental gamble," but as a metal which is now beginning to hold its own in industry. The cost of production has been the greatest problem, but this will eventually be solved. Titanium has not lived up to the expectations given it eight years ago; yet those predictions were not entirely worthless. It might be well to look at the industrial progress of the metal since its discovery in the last part of the eighteenth century.

II. History of the Metal

Reverend William Gregor, a minister and an amateur mineralogist, first obtained titanium in 1789 from a black beach sand (ilmenite). Its present name "titanium" was not given it until several years later when a German chemist, Kalproth, discovered Greger's same new element in the mineral rutile. Even as early as 1797, chemists and metallurgists, trying to obtain titanium from its ores, thought that they had actually obtained the pure metal. However, the properties of their pure metal as described in their recorded experiences were not the same as the properties of pure titanium as we now know it: theirs was not the pure metal. In fact, it was not until 1887 that a metal 94.7 per cent pure was obtained.

III. Chemical Nature of Titanium

The long period of time between the actual discovery of titanium and its development to 95 per cent purity is perhaps justified by its very active chemical nature. Oxygen and nitrogen from the air readily combine with the metal, particularly at high temperatures. Also, the molten metal appears to be a universal solvent; every known refractory either contaminates it or is dissolved by it. Although aluminum and magnesium have the same reaction with oxygen at high temperatures, these metals, if left to stand under suitable conditions, will separate from the oxygen. This is not so with titanium. The oxygen dissolves in titanium and no amount of settling will remove it. It is extremely important, however, that the impurities be strictly limited because the impure metal at room temperature is very brittle and, of course, as such is useless as a structural material. Nevertheless, even though this problem seems great, there are reasons why this metal has been given so much importance.

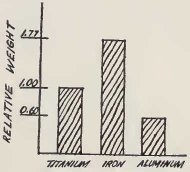


Figure 1. Relative Weight of Equivalent Volumes of Titanium, Iron and Aluminum.

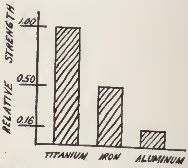


Figure 2. Strength of Titanium Compared to Iron and Aluminum.

IV. Importance of Titanium to Industry, Including Properties of the Metal

Titanium is not a scarce metal; in fact, it is the fourth most abundant structural material in the lithosphere, exceeded only by aluminum, iron, and magnesium. While the other structurally useable elements such as copper, lead, zinc, tin, and others, lumped together, comprise less than 0.11 per cent of earth's crust, titanium itself accounts for 0.62 per cent. Although the element is for the most part thinly distributed, only a few titanium-bearing minerals being in large and rich enough bodies to be worth mining (rutile and ilmenite are the principal titanium-bearing minerals). As can readily be seen, the production of pure titanium presented a great problem; yet we Americans were placed into such a position that this problem concerning the metal had to be solved.

In bringing about the final defeat of World War II, this nation had drawn heavily upon its mineral resources. The high and medium grade ferrous ores were reduced such that the self-sufficiency of the nation was seriously threatened; high grade ores of the nonferrous metals were in a demand far greater than present ability allowed them to be produced. Of course, the production of aluminum and magnesium as lightweight peacetime products became increasingly important; however, these metals would not substitute for steel and the nonferrous metals where prime importance is placed on some special property such as hardness, workablility, corrosion resistance, or unusual strength. Titanium appeared to be the solution to the problem; this metal combines the properties of stainless steel with those of strong, light aluminum alloys.

Titanium has three of the most important characteristics of a structural material; strength, lightness and corrosion resistance (see Figs. 1 and 2). If strength alone is considered, titanium is heavier than aluminum alloys and is, therefore, not generally superior to them. Nevertheless, for applications which require corrosion resistance and resistance to heat up to 1000°F, titanium is by far the superior. Lighter than stainless steel, titanium can be produced comparable in strength; it can easily replace stainless steel, considering only a metal with a high strength-weight ratio that can stand temperatures ranging from room temperature up to 1000°F. In most corrosive mediums the corrosion resistance of stainless steel is either equalled or excelled by that of titanium. In fact, metallurgists generally report that under certain conditions titanium is one of the most corrosion - resistant commercial metals available. It must be added, however, that titanium is subject to stress corrosion. This fact is important, but the metal is still relatively new and problems can be expected to arise.

IV. Commercial Production of the Pure Metal

With a few modifications Knoll's process for reduction of rutile, actually developed in 1940, is still used for the commercial production of titanium. This process, as illustrated in Fig. 3, consists of three main steps: (1) titanium sponge must be produced, (2) the sponge must be purified, and (3) the sponge must be melted into solid metal ingots. At present the standard of the titanium industry is the double - melting process which Mallory-Sharon introduced. The actual melting opera-

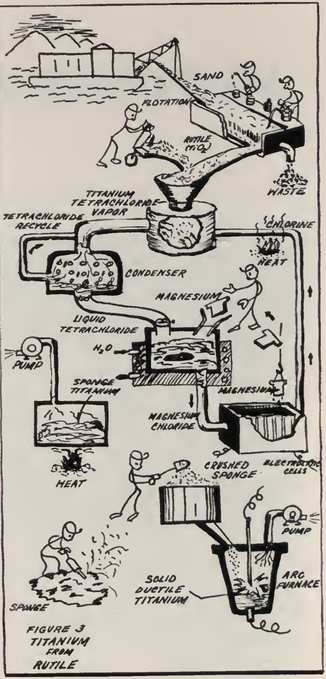


Figure 3—Flow Diagram—Present Industrial Practices. Based on Rutile as the Source Material.

tions are conducted in heavy vaults, the furnaces being remotely controlled from a master panel. This minimizes personnel hazards and also assures continuity of production.

In October of this year a new process was described to the Electrochemical Society in Cleveland. Ilmenite instead of rutile, is used in the process, reduction by a Acheson-type furnace. At present rutile ore is used because it is purer and easier to process, and yet it is much more expensive than ilmenite (cost per ton rutile = 10 x cost per ton ilmenite). Other processes are also being investigated, but there has been no commercialization of them as yet.

(Please turn to page 34)

"SO YOU'RE AN ENGINEER!"

by Mrs. Marjorie Rhodes Townsend B. E. E. '51

"So you're an engineer! Do you build bridges?" I can't count the times I've been asked a question like that one, or this one: "Someone told me you're an electrical engineer — do you fix your own television set?" This seems to be the ultimate accomplishment an engineer can claim. This latter question comes from more enlightened individuals, and is considerably closer to the truth than the first. As a matter of fact, we have managed to keep our set out of the shop. My obstetrician-husband is turning into an excellent TV repairman and, with a little more training, he'll be able to fix ours without any coaching. However, lacking the proper test equipment at home, we refrain from working on other people's sets.

The general public is becoming more educated to women in science, but "ohs," and "reallys" are still generated when I am introduced as an engineer. The picture which the thought of a woman engineer conjures up must be a sister to the "Wicked Witch of the West." When I was out in California this fall to give two papers at the Symposium on Underwater Sound, a high school friend of mine, now living there, very graciously gave a cocktail party for me. None of her friends were "in science," and all she told them was that I was an electrical engineer. Apparently they were amazed to find that I was a human being also.

Now that I have mentioned Underwater Sound, I had better explain myself a little. Three months before I was graduated from G.W.U. with a B.E.E. (Communications), I went to work in the Sound Division of the Naval Research Laboratory. My job as an "electronic scientist" is to help develop improved sonar displays and techniques that are applicable to antisubmarine warfare. It is extremely interesting and challenging work. (For the benefit of the girls reading this, I'll add a few remarks. During the six years I've been with the Naval Research Laboratory, the increased responsibility of my work and my promotions have kept pace with the rest of the engineers in my group). My only regret is that I am not always able to carry my share of the load on field trips. The Navy is extremely narrow-minded about taking women out on their ships — that, at least, is still a man's domain — but these barriers are slowly being dissolved, and it is now possible to go out on one-day trips. Thus the disadvantage of being unable to see the equipment in actual operation is disappearing. And, I must admit, the thought of leaving my three small boys for five or six weeks is not at all appealing.

Many women have the ability to be engineers. All it requires is an interest in and aptitude for mathematics and science. Unfortunately, the idea that it is strictly a man's field still exists and keeps many good potential engineers away. True enough, some of the more rugged phases might not be attractive to women, but the field of electronics is wide open and growing rapidly. Working with miniature and sub-miniature tubes and components, and the fast-growing field of transistors, could be excellent fields for women. The design and testing of electronic circuits and systems can be very challenging and exciting work.

As the situation exists now, you will occasionally feel that you are in a golffish bowl. If you have an opportunity to attend many meetings, you'll find that a great many people, whom you have never met, know who you are. When the chairman at a meeting says. "So you're the lady engineer — well, well, well!" you might look around for one of those wells to sink into. The consolation of these remarks is that you *are* a lady, and are treated as such. The men with whom I work are careful to make sure that I don't lift anything too heavy, and are generally quite considerate.

(Please turn to page 36)

— do you fix your own television set?

A WOMAN STUDIES ENGINEERING

This is Claire Lee Chennault, a sophomore in the School of Engineering. Claire is one of the many young women of today who are turning to engineering as a career instead of teaching or social work. Claire is pictured here in a Drawing Lab. Although as a sophomore she is not taking Mechanical Drawing or Descriptive Geometry, like any other engineer she spent plenty of time on these two courses in her freshman year.

A busy day for Claire begins with a class in Dynamics at 9:10 a.m. Claire is the only girl in her class which is held in the new Tompkins Hall of Engineering. Here Professor Hardy explains a problem in Dynamics to Claire. As a sophomore this is the only "real" engineering subject she is taking. The rest of her courses are requirements for the Bachelor of Science in Engineering degree which she hopes to get in another three years and include physics, speech and English.

Claire is a sophomore in the School of Engineering and is planning on taking the degree of Bachelor of Science in Engineering, although she has not yet decided on a group option. She is really interested in going into architecture, because she feels that in architecture she can "see" what she is accomplishing. Before she goes on to an architectural school, however, she will get her degree from G. W.

Claire's father is a colonel in the Air Force and the well-traveled Miss has lived in Germany and Spain and toured most of continental Europe. She has also been to Tangiers in what was formerly Spanish Morrocco, which she thinks is the most

Claire skims quickly through her Spanish book over a cup of coffee in the Student Union. She waived her basic Spanish requirements and is now taking Spanish Conversation. This is the only elective course that Claire can take during her sophomore year. She chose Spanish because her father, a Colonel in the Air Force, is stationed in Madrid, Spain, and she plans to spend her summers there with him.

Demerits are posted on the Bulletin Board in the Air Force ROTC Building. Once a week at least Claire must check the board to see how many more demerits she has—usually quite a few, she says. Claire is a member of the Angel Flight, a women's basic AFROTC group which drills once a week either at the University or on the ellipse. If she decides to go on with her AFROTC next year she will become a member of the women's cadet corps. As a cadet she will receive the regular Air Science instruction offered at the University and upon graduation will be commissioned a second lieutenant in the Air Force.

fascinating place in the world.

Her family lives in Madrid, Spain, right now and she spends her summers there with them. She has become a great "aficionado" as far as bull fights are concerned and can talk learnedly of bulls and bullfighters. Her favorite is one of the newest "greats," Gregorio Sanchez.

At school, in addition to being in Zeta Tau Alpha, social sorority, and on the Engineer's Council, she is a member of Big Sis, a freshman orientation group, and Flying Sponsors, a women's ROTC social group. Just lately, among other things, she was one of the five candidates for AFROTC queen.

One Wednesday evening every month finds Claire at the Engineer's Council meeting. She is one of the two sophomore representatives on the Council this year. Here Claire concentrates on a report by Tony Lane (she thinks but can't really quite remember who was talking), Engineer's Representative to the Student Council.

In the physics laboratory Claire examines one of the models used to demonstrate crystal structure. Claire is taking Physics 8 now, the last in a series of four basic physics courses. Physics 8 is one of the prerequisites Claire must have for an upper division physics couse in Electronics she must take during her junior year.

Tuesday and Thursday nights generally find Claire practicing with the University's Glee Club. The group's last performance was at the Cherry Blossom Festival where they sang such old favorites as "Dancing in the Dark," "Blue Skies" and "April in Paris." Claire lives constantly in fear that "Doc" Harmon, director of the Glee Club will notice her and make her stop singing — she has a terrible voice, she says. However we doubt that fact. She also sang with her sorority for the annual University Panhellenic Sing. After Glee Club practice is over, Claire will return to the dormitory to put in three or four hours of good, hard study before she goes to bed, unless she is too tired, in which case she will either knit or make plans for the wonderful summer ahead in Spain with absolutely no physics, dynamics or calculus to worry about.

PARTNERSHIP ENGINEERING

By Mrs. John E. Manning

Most women will adjust the setting of the furnace thermostat with little thought of possible enthalpy changes, or start the electric range with no appreciation of hysteresis losses; however, there is a small (but ever increasing) group of women who take cognizance of these common engineering principles. These technically minded women, however, are not engineers by profession. They have no engineering class hours to their credit, but have withstood a vast accumulation of study hours. They've aided in the prepartion of countless assignments, yet have never received a grade. Their graduation day is very real, although their name will appear on no diploma. This enterprising group of "students" can be identified as "women engineers-by-marriage."

A woman-engineer-by-marriage is one who is aiding and abetting an engineering student husband toward that glorious day when he is in a position to thrust out an eager hand for "their" well-earned diploma. (And no blocking of the aisles when that day comes!).

Whether our engineer-by-marriage be gainfully employed or on the job full time at home, her contribution toward that diploma is very real. She constantly attempts to pave the way for her husband's successful study by doing such things as minimizing everyday distractions during "pre-exam seclusions" and remaining on call to lend a secretarial hand if needed.

Some whom this article will reach are doubtlessly already working on their "honorary degree" in engineering; others may be contemplating the possible acquisition of one. To those currently engaged in the foray, I extend understanding and encouragement; to those who are about to join the ranks, I offer a welcome, more encouragement and a few observations. And for those who are innocent bystanders, perhaps there is an occasional enlightening thought herein.

Before proceeding to the practical and more specific aspects of the situation, it should be pointed out that while assuming partnership with a student husband definitely requires something extra on the part of both in hard work, selflessness, patience and the saving grace of good humor, it also affords a unique challenge and opportunity. The challenge seems to be that of keeping a very full life in proper balance. The opportunity is primarily in the new horizons that are unfolded

Now for some observations on the problems and situations that these women engineers-by-marriage might well be confronted with during this educational ascent.

First of all, it definitely is an asset to be able to type and above all to be deft with the variable line spacer. If you type the text of the problems for him (and an engineer is assigned at least 3×10^{10} problems during his Tompkins Hall career) you'll find that they're fraught with knotty equations. The majority of these equations have superscripts and subscripts and even the subscripts have subscripts. Incidentally, it is also a very good idea to let the *real* engineer do the proofing of any typing you might do for him. From an appreciable amount of experience it has been ascertained that it is possible to omit words, phrases or even whole sentences and the typist remain blissfully unaware of it when re-reading.

Another skill, so to speak, that will prove its worth is the art of printing. This may sound elementary, but we are looking at it from the standpoint of degree of accomplishment. The goal here is to be able to print symmetrically and even decoratively as the occasion demands. It is mandatory from the standpoint of one hundered per cent communication, as you'll find that almost any engineer is a devotee of printing. It will assure you, for instance, a reduction in the number of items you still have to shop for that were on that grocery list you gave him. So, if your printing is a bit substandard, keep practicing, and when he asks you to print the data on the cover of his lab folder, you'll know you have arrived.

There'll be a wonderful opportunity to enlarge your vocabulary and number of concepts. From the standpoint of time and rate of absorption, however, it might be feasible to let some of this enlarging end at the opportunity. This seems justifiable as a passing acquaintance with and recognition of is more often your goal, rather than complete understanding. It is disconcerting, however, if you've felt that you possessed at least an average vocabulary, to hear a multiplicity of totally unfamiliar words or familiar words given an unfamiliar meaning. So, stick with it and listen and before long even such words as extrapolate, isentropic and heterodyning will have a friendly sound.

You may find that an occasional glance through an engineering publication will help you to establish rapport with the profession. If nothing else, it will help you to feel less martyred when you literally haul those weighty professional journals in from the mailbox up that flight or two of steps. Also your expressions of sympathy to the mailman can be more sincere. So, the next time you find youself reaching for *The Ladies Home Journal*, think better of it and pick up that special transactions issue on computers instead. (On second thought, this suggestion is probably totally for naught, for, after all, who has the time to even *reach* for *The*

(Please turn to page 30)

MAGNETIC RECORDING

By Francis Mikalauskas, B. E. E. '57

Magnetic recording had its beginning in 1898 with the invention of the "Telegraphone" by Valdemar Poulsen, an engineer of Denmark, who has frequently been referred to as the "Danish Edison." The puzzle as to where or how Poulsen got the idea of recording sound by varying the magnetization of a steel wire remains unsolved. During his experimentation with the telegraphone, the knowledge of magnetism was very limited. It was the accepted theory that if a bar magnet were subdivided into its smallest parts these pigmy magnets would be of equal strength. And if it were possible to join them together again one magnet would result. Maybe Poulsen thought it was not necessary to magnetize the whole bar at a time. Maybe, if the material were magnetically "hard" enough, it would be possible to magnetize just one small area of the material and leave the adjacent areas unaffected by the magnetizing force. Perhaps this reasoning led him to investigate the possibility of magnetizing a steel wire to different degrees so close together that sound waves could be recorded on it and thereby to invent the telegraphone.

Poulsen's telegraphone consisted of a large, stationary, brass cylinder in which a steel wire was embedded in a spiral groove that ran along the length of the cylinder. Lying against this wire was an electromagnet

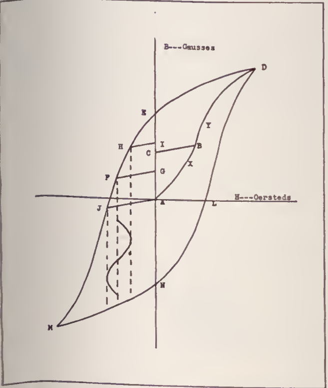


Figure 1. Hysteresis loop for a typical magnetic material.

that was made to follow the wire in its spiral path by a suitable mechanism driven by a spring motor. Sound waves, striking a telephone mouthpiece, produced currents that caused the electromagnet to magnetize the wire by amounts corresponding to the strength of these currents. Upon completion of a recording, the mouthpiece was switched out of the circuit and a telephone earpiece was connected in its place. Then, by replacing the electromagnet at the beginning of the wire spiral and playing the record through again, the original message was heard, as the varying magnetization of the wire generated currents in the electromagnet.

For most practical purposes, magnetization is a reversible process and the wire could be used again for a new recording by simply demagnetizing it. Since there was no demagnetizing force present during playback, the records were more permanent than the existing mechanical recordings. Poulsen probably had no idea how permanent his magnetic records would be. Early literature concerning his telegraphone records is filled with references to an expected life of hundreds of playings, but states that the quality could be expected to decrease thereafter. Subsequent measurements have shown that hundreds of thousands of playings can be made without a substantial loss in the quality of magnetic records.

Poulsen's idea was an amazing one, and it was his alone! Time and time again an invention has been made independently and almost simultaneously by two or more men, but no one else, so far as is known, has challenged Poulsen's telegraphone. By the standards then prevailing, it was a remarkable advancement in the recording of sound. Everyone who heard it noted the naturalness of the reproduction and the freedom of noise as compared to the Edison phonograph of their day. As a machine to record and play back speech, the telegraphone had two distinct disadvantages. The sounds it made were no louder than those of the telephone earpiece, and the wire had to run so fast that it took as much time to rewind it for playback as it did to make the recording itself. The first of these difficulties was overcome by Dr. Lee De Forest's audion and the electronic amplifier which followed; the second by the development of materials which were harder magnetically than carbon steel (today's magnetic tape is approximately ten times as hard as Poulsen's wire) which meant that everything could slow down.

For musical reproduction magnetic recording had an even more serious defect. The magnetic flux density retained by the wire did not automatically match the strength of the signal fed into the electromagnet—that is, doubling the strength of the signal did not double the magnetic flux density that was retained in the wire. This nonlinearity was the prime cause of distortion in

Poulsen's machine. But the graph that measures magnetic field intensity against magnetic flux density does have one area in which it is straight, in which the wire is linear. It was Poulsen, in 1907, who invented the first device for "biasing" the wire to bring it into this area of linearity.

There have been many improvements on Poulsen's telegraphone in the magnetic medium used, the method of recording, and the driving mechanism. From a study of Poulsen's machine and the magnetic tape recorder of today, the theory of magnetic recording may be expressed as follows. To be recorded, signal currents produced by a microphone are passed through a magnetic coil wound on an iron core, "head." A magnetic tape or wire is drawn past the poles of the head, and the varying currents are recorded as varying degrees of residual magnetism contained by the magnetic medium. To reproduce the original signal, the tape or wire is drawn over the poles of a similar structure, and the magnetic impulses generate a varying voltage in the head. In most cases, this signal voltage is then passed through an amplifier to raise it to a usable level for driving a speaker which reproduces the original signal.

SOME BASIC MAGNETIC RELATIONS

At this point it may be well to review our knowledge of magnetic characteristics so that there will be a clearer understanding of the terms that will appear in this article.

The symbol for magnetic flux density is "B", while the symbol for magnetic field intensity is "H." These magnetic characteristics of a material are essential to any discussion of magnetism and they are plotted together to form the very familiar B-H curve. The unit of magnetic field intensity or magnetizing force is the "oersted" (H), and the unit of magnetic flux density or magnetism is the "gauss" (B). A magnetizing force of one oersted will produce magnetism of one gauss—one magnetic line per square centimeter of cross-sectional area—in air.

It is interesting to note the similarity of the B-H curve to that of plate voltage versus plate current curve of a vacuum tube. The linearity falls off both as the curve approaches zero and as it approaches saturation. This is a potential source of distortion, but we shall see how it is overcome in the discussion of "biasing" of the magnetic medium.

Referring to Fig. 1 we see the hysteresis loop of a typical magnetic material. Beginning at point A, with the material demagnetized, the magnetizing force (H) is increased to point B and then reduced to zero. The material, however, has become permanently magnetized and the flux density (B) does not return to zero but instead only drops to a value of point C. The failure to retrace is known as hysteresis, and a curve of this type is often called a hysteresis loop.

If the magnetizing force had been increased to point D and then reduced to zero, the residual flux density would now correspond to point E. Note that (B), the residual flux density, is not proportional to (H), the magnetic field intensity. As already mentioned, this is a source of nonlinearity. From the origin to point X the characteristic is very nonlinear. Between X and Y the linearity is excellent, and after Y it again becomes nonlinear. Obviously, for good reproduction, some biasing is necessary to enable operation on the linear section of the curve.

BIASING

Two systems—one using DC and the other an ultrasonic bias—have been developed and are widely used. The d-c bias employs a saturation erase. The material in passing the erasing head is magnetized to point D of Fig. 1 and therefore will return to a residual flux density of point E. (D, E, M, N.) is the hysteresis loop of the material.

In order to operate on the linear portion of the loop to the left of point E a fixed negative field, F, is applied to the material by the recording head. When the material leaves the recording head, the flux density decreases along a nearly straight line to point G. For example, suppose a signal superimposed upon the fixed negative bias varies the field intensity between H and J. If the material leaves the influence of the recording head polepieces when the field intensity is at point J, the flux density proceeds along a practically straight line to point A. From point H it would go to I. Within a limited range in the neighborhood of point F the lines H-I, F-G, and J-A will be almost straight and parallel. This means that the induced reproducing voltages will be linearly related to the recording fields.

Of great importance is the magnitude of the fixed negative bias employed. If this bias is too small, the signal will be distorted by the nonlinear section near point E. Too large a bias will cause signal distortion by carrying over into the section near M. There is a limit to the magnitude of the recording audio field, for the curve is linear only in a limited region around point F. In addition, too large a field will produce distortion. There is one fundamental objection to d-c bias. When there is no signal, the tape is nevertheless recorded and left in a magnetized condition. Unfortunately, a magnetized tape is noisier than an unmagnetized one, so that the signal to noise ratio is approximately 10 db poorer than it would be if the tape were left unmagnetized when no signal was being recorded. Therefore, d-c bias has become obsolete to a great extent.

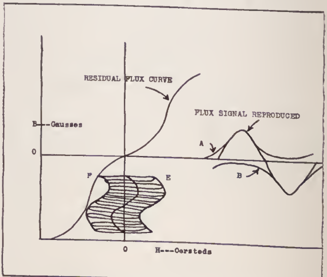


Figure 2. Action of ultrasonic biasing.

In 1927, Carlson found that the nonlinearity of the magnetization curve could be eliminated by applying a high frequency current to the recording head while recording a signal. Thus, ultrasonic or a-c biasing was developed. It possesses several advantages over d-c bias. Ultrasonic biasing, as its name implies, makes use of an ultrasonic signal (40 kc is commonly used) as a bias upon which the audio signal is superimposed. Normally the ultrasonic oscillator is also used for the erasing head, so that the magnetic material enters the recording head completely demagnetized.

Fig. 2 illustrates the action of ultrasonic biasing. Here is a field which is a mixture of the ultrasonic bias and an audio signal is shown applied to the residual flux density curve. Let us first consider the magnetizing action of a typical tape record head. The demagnetized tape entering the head will be shielded from the magnetic field until it enters the recording gap between the two pole pieces. During the time in which it travels from the first pole to the shielding of the second pole. the element of tape will be subjected to the varying magnetic fields existing in the gap. In this time interval the audio signal amplitude will have changed by only a small increment. However, the ultrasonic bias will have gone through one and one-half to two cycles. The residual flux density that is left in an element of tape will depend upon the field intensity existing in the gap at the instant that the element left the gap and entered the second pole. This is essential to remember. This means (referring to Fig. 2 again) that if one element of tape had a residual flux density corresponding to a field of point E, the residual flux density of the following segment would correspond to point F.

But what effect does this have upon reproduction? We find that the gap is long enough to contain several negative and positive peaks of the ultrasonic bias. The total flux in the gap will then depend upon the sum of the gap fluxes. In Fig. 2 the projection of the positive peaks on the residual flux curve at each instant of the audio signal produces curve A. The projection of the negative peaks forms curve B. The addition of curves A and B results in a curve that represents the effective flux that the tape will reproduce in the gap. Although some distortion is present in the resultant curve, it is a great improvement over reproduction without bias. As in d-c biasing, the linearity of the response using ultrasonic biasing is dependent upon the amount of bias used. The response shown in Fig. 2 probably could be improved upon with a more careful choice of bias.

Erasing

Erasing is very simple in principle, but in practice considerable effort must be expended to secure the best results. An incomplete erasing will leave remnants of the previous recording, which will show up as noise.

The basic method of erasing is to magnetize the tape to saturation, then reduce the magnetization to the desired value. In the early development stages of magnetic recording it was customary to use a d-c erase, and the saturating field was produced by a strong permanent magnet. The residual magnetism left on the medium was then reduced to the desired point by a suitable d-c bias current through the recording head. This method, of course, was suited only to d-c bias use, and is now practically obsolete.

In a-c erasing the magnetic medium is subjected to an a-c magnetic field of decreasing intensity. For a time the field is strong enough to saturate the tape, and hence obliterate all previous recording. The medium is then carried through many hysteresis loops of constantly smaller size until at last the tape is left at zero magnetization.

Such magnetic flux variation is produced by passing the tape over a suitable magnet excited by current of ultrasonic frequency. With a-c erase it is essential that the first cycle or two be enough to saturate the tape. Otherwise, the erasure is not complete, and the background noise will be objectionable.

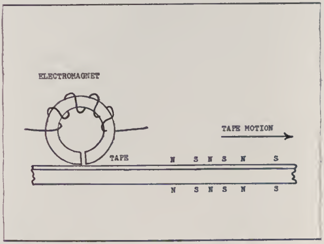
Magnetization Methods

Two methods of magnetization of the magnetic medium have been used in the past: Transverse and logitudinal. However, practically all tape recorders today employ longitudinal magnetization, and for that reason it will be expedient to confine our attention to this mode of magnetization. In longitudinal magnetization the magnet poles are spaced along the length of the tape, and the direction of magnetization is along the length as in Fig. 3. As mentioned before, the magnet pole and coil assembly is usually called a "head." The magnetic track produced by a head is only minutely wider than the head itself, so that several tracks may be appiied to a single tape by using narrow heads side by side on a wide tape. By this method ten or more tracks may be applied to a tape one-quarter of an inch wide. Sometimes the heads are staggered in position, rather than side by side, so that the tracks may be placed closer together without one head interfering with the next.

Design Considerations for Frequency Response

Much of the performance of a magnetic recorder depends on the performance of its recording and reproducing heads. An important dimension of the reproducing head is the "gap" width, which controls the high frequency response. The recording head is not as critical in this respect. Thus, while a 0.00025 to 0.0005 inch gap is used in a good reproducing head, the recording head may have a 0.001 inch gap. At frequencies where the gap width approaches and exceeds

(Please turn to page 24.)



Firgure 3. Magnetic recording using longitudinal magnetization.

What's doing.

Schlieren photographs, above and left, illus-
trate different phases of airflow investigation.
Development of inlets, compressors and tur-
bines requires many such studies in cascade
test rigs, subsonic or supersonic wind tunnels.

... at Pratt & Whitney Aircraft in the field of Aerodynamics

Although each successive chapter in the history of aircraft engines has assigned new and greater importance to the problems of aerodynamics, perhaps the most significant developments came with the dawn of the jet age. Today, aerodynamics is one of the primary factors influencing design and performance of an aircraft powerplant. It follows, then, that Pratt & Whitney Aircraft — world's foremost designer and builder of aircraft engines — is as active in the broad field of aerodynamics as any such company *could* be.

Although the work is demanding, by its very nature it offers virtually unlimited opportunity for the aerodynamicist at P & W A. He deals with airflow conditions in the engine inlet, compressor, burner, turbine and afterburner. From both the theoretical and applied viewpoints, he is engrossed in the problems of perfect, viscous and compressible flow. Problems concerning boundary layers, diffusion, transonic flow, shock waves, jet and wake phenomena, airfoil theory, flutter and stall propagation — all must be attacked through profound theoretical and detailed experimental processes. Adding further to the challenge and complexity of these assignments at P & W A is this fact: the engines developed must ultimately perform in varieties of aircraft ranging from supersonic fighters to intercontinental bombers and transports, functioning throughout a wide range of operational conditions for each type. Moreover, since every aircraft is literally designed around a powerplant, the aerodynamicist must continually project his thinking in such a way as to anticipate the timely application of tomorrow's engines to tomorrow's airframes. At his service are one of industry's foremost computing laboratories and the finest experimental facilities.

Aerodynamics, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of instrumentation, combustion, materials problems and mechanical design — spells out a gratifying future for many of today's engineering students.

Modern electronic computers accelerate both the analysis and the solution of aerodynamic problems. Some of these problems include studies of airplane performance which permit evaluation of engine-to-airframe applications.

Design of a multi-stage, axial-flow compressor involves some of the most complex problems in the entire field of aerodynamics. The work of aerodynamicists ultimately determines those aspects of blade and total rotor design that are crucial.

Mounting a compressor in a special high-altitude test chamber in P & W A's Willgoos Turbine Laboratory permits study of a variety of performance problems that may be encountered during later development stages.

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OUT OF THE BRIEFCASE

SINGLE SHELL CONDENSER

The world's largest single shell condenser will be part of the addition of a new unit (number 3) to the Rouge River Power Plant of The Detroit Edison Company. The addition will increase the gross guaranteed output of the plant to 840,000 KW.

The massive condenser, built by Worthington Corporation, has 170,000 square feet of surface and will contain nearly 22,000 — 40 foot Admiralty tubes, which alone weigh over 180 tons and, laid end to end, would stretch 165 miles. Completely assembled, the condenser occupies a space 34 feet high by 26 feet wide and 69 feet long, with a dry weight of nearly 600 tons, and when in service, nearly 1000 tons.

Steam will be exhausted to this condenser from an Allis - Chalmers cross-compound reheat turbine generator designed for 2400 psig 1050 F steam at the throttle, and rated 320,000 KW capability at 1.0 inch Hg. absolute back pressure. A net plant heat rate of 8620 Btu per KW hr. is expected from No. 3 Unit, some 260 Btu lower than for Units 1 and 2, each rated 260 Mw capacity. This would not be possible without the condenser, which, in addition to permitting the steam to expand to a very low pressure, also changes it into oxygen free condensate for reuse as feedwater to the boiler.

Two 80,000 GPM Worthington vertical HIFLO pumps will circulate 159,000 GPM through the condenser, removing heat at rates up to 1300 million BTU's per hour.

Vertical two-stage rotative dry vacuum pumps motor driven, will maintain the vacuum required in the condensers serving all three units at Rouge River.

RCA's BIZMAC

The world's largest electronic "brain" was demonstrated publicly for the first time last month by the Army Ordnance Corps which estimated that the new system would save "many millions of dollars."

The $4.0 million electronic data processing system, known as Bizmac, was built by the Radio Corporation of America and is installed at the Army Ordnance Tank-Automotive Command headquarters in Detroit.

Worlds Largest Electronic "Brain."

At electronic speed, the RCA Bizmac system can take inventory, catalog spare parts, prepare manuscripts for catalogs, forecast supply requirements and produce budget summaries. The system can complete in forty-eight hours an inventory procedure that once took up to three months and handle in a half-hour a price calculation that used to take a clerk five weeks of steady work, says Charles S. Diehl, Chief of OTAC's Electronic Data Processing Branch. It can also process by computer in one hour as much work as 400 girls with hand calculating machines could turn out in the same time and record information on magnetic tape and read from tape as much information at 1,700 words per second—a rate at which it could finish Tolstoy's "War and Peace" in about five minutes.

The Bizmac system includes four basic units: Input Devices for preparing and feeding information and instructions into the system; Storage Devices for filing information within the system so that it is readily accessible on demand; Data Processing Devices for sorting and computing as dictated by instructions; and Output Devices for providing finished copies of the information required.

TRANSDUCER SYSTEM

Rate of pressure changes can now be measured directly with a new SLM Transducer system introduced by the Kistler Instrument Corp. of Tonawanda, N. Y.

Through the use of an adaptor and resistor element, the electrical current (rate of change of charge) generated in the Swiss-made quartz crystal transducer is measured by an "electrostatic" type amplifier and displayed on a standard oscilloscope or recorder.

Featuring fast response and high sensitivity, this instrument is described as being extremely valuable for studying cylinder processes on engines and compressors. It will be especially useful for indicating combustion and detonation phenomena in the evaluation of new engines and fuels. Other applications include shock tubes, gun tubes, rocket motors and hydraulic or pneumatic systems.

The Electronic Classroom–RCA adds a new world of sight and sound to the "3 R's"

Today's classroom is no longer bounded by books and blackboards. For our children, school is big as the world of sight and sound itself.

RCA has sent the electron to school —in TV sets, radios, "Victrolas,"® records, tape recorders, film projectors. And with all this, valued help for teachers who must make fullest use of our overcrowded classrooms.

Picture a civics class listening to a vital debate in the UN . . . a youngster improving his diction with the help of a tape recorder . . . kindergartners dancing to folk music of a faraway country . . . internes watching an operation close-up on closed-circuit TV. . . . The applications are endless.

Through its leadership in electronics, RCA contributes a great deal to the success of this new and broader kind of education. In fact, helping our oncoming generation to see, to hear . . . to understand . . . is one of the most important jobs we do. TMK(S)®

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Electronics for Living

MAGNETIC RECORDING

(Continued from page 19)

one recorded wavelength in size, the frequency response is impaired.

Faulty contact between pole pieces and tape has an equally bad effect. Even as little as 0.001 inch space between a pole and the tape will have a major effect. For this reason a lacquer coating over the magnetic medium (lying between it and the poles) is out of the question.

Frequency response is critically affected by the azimuth alignment of the gap used for recording and reproducing. Professional machines generally have means for azimuth adjustment of the heads. Home tape machines, however, very seldom have provision for such adjustment, so that a tape recorded on one home machine and played back on another with a different angle between the gap and the direction of tape travel will generally reproduce poorly, with most of the highest frequencies lost.

Response is affected by tape speed, particularly at the higher frequencies. The effect of increasing tape speed is to increase the frequency of maximum response. The shift is directly proportional to speed, hence the frequency of peak response will be doubled when the tape speed is correspondingly changed.

Recently, manufacturers have found that improved heads lead to a great increase of usable frequency range. Thus, home machines using tape speed at 3.75 inches per second may have good response up to 6 or 7 kc, and professional machines running tape at 7.5 or 15 inches per second may have uniform response up to 10 or 15 kc. Machines of this type are relatively new, and not yet a major part of the field; they are all characterized by the improved quality of the reproducing head. The physical modification of the head is almost imperceptible — reducing the gap width by several ten-thousandths of an inch — yet it is adequate to double the available frequency range for a given tape speed.

Advantages of Magnetic Recording

Magnetic recording has certain advantages not possessed by either mechanical or optical recording. Some of these advantages, such as the ability to erase, are absolute, in that they are not exhibited by the other systems to any degree whatever. Others, such as possible frequency range, are relative, being achievable in other systems, but only at the cost of considerably more difficulty than is involved in a magnetic-recording system. These advantages may be listed as follows:

1. A previous recording can be erased and the medium used over again as often as desired.
2. The number of times that magnetic recording can be reproduced without serious deterioration is praccally limitless.
3. The frequency range that can be handled can be increased greatly by making the speed of the medium sufficiently high.
4. Magnetic recording is a true "instantaneous" recording system in that (apart from the rewind time, if any) the recording can be reproduced as soon as it is made.
5. Slight attention on the part of the operator is required during the recording process.
6. Magnetic-recording equipment can operate under more severe conditions of temperature and vibration than any other recording system.
7. When necessary, magnetic-recording equipment can be made extremely compact.
8. Little power is required to make a magnetic recording.
9. Splicing and editing of a magnetic tape are quite easily accomplished.

These advantages, particularly the erasing feature, enable magnetic recording to be applied under many conditions where other recording systems would function inadequately because of the technical difficulties involved.

Applications of Magnetic Recording

Time Delay

A signal to be delayed is applied to the recording head. A playback head is stationed along the sound track at a distance from the recording head equal to the velocity of the medium divided by the delay time required. Time delays (from a small fraction of a second to almost any time desired) can be effected by this means.

Artificial Reverberation

A signal is recorded on an endless magnetic loop and is picked up by playback heads spaced at varying distances from the point at which the signal is applied to the loop. The output from all of these heads is mixed, and the resulting signal has many of the qualities of reverberation, since each additional head in effect adds an echo whose delay is determined by its distance from the recording head.

Speech Scrambler

Another application of multiple time delay is the speech scrambler. This device, which was developed as a means of achieving secrecy in radio communication, passes the speech signals to be scrambled through selective audio band filters and then delays the components in each band by different amounts before they are transmitted. The result is quite unintelligible gibberish. At the receiving end the components in each frequency band are again delayed by the proper amounts to make them emerge in their original order.

Announcing Mechanisms

There is a broad commercial demand for instruments that repeatedly produce a message, either continuously or at predetermined intervals, when initiated by some particular means. Magnetic recorders of the endless-loop or other equivalent type are generally preferable to recorders using other means of recording when the messages have to be changed at frequent intervals, or when the same messages must be repeated many times without deterioration in quality.

Magnetic "Memory"

Magnetic recording can be used advantageously in many situations where a "memory" device is needed to store electrical signals for a time. In complex electrical computing devices, it is often necessary for the

(Please turn to page 26)


VANGUARD

HEADACHE CORNER

By Sy Matthews B.S.E. '57

If last month's problems were too easy for you then don't bother to read the rest of this article. The problems will be much too easy for you. and you will certainly be bored if they are not challenging.

Three students had failed a course given by Professor Howcome. Feeling that the students should be given one more chance to show that they had gained at least a small bit of knowledge in his course and having a weird sense of humor. he decided to give the students passing grades if even one of them could pass a special test. The students were blindfolded; each then selected and put on his head one hat from five (the students were told that three were red and two were green), which were on Professor Howcome's desk. After the two remaining hats were placed in a drawer, Professor Howcome told each student to remove his blindfold and, by viewing the hats on the other student's heads, to tell him the color of the hat on his own head. Two students removed their blindfolds, but neither knew the color of his own hat. Then the other student, without removing his blindfold, told Professor Howcome the color of the hat on his head. Professor Howcome was so pleased that he passed all three students. What was the color of the third student's hat? Howcome?

Ed and Joe lived in a house located by a road on which only Fords, Buicks and Chevrolets travelled. Joe could identify all cars that went by, but Ed was unsure of the identity of some. Ed called those which could not be identified "Drags." One day Joe and Ed sat on their front porch and watched the cars pass. That night Ed turned to Joe and said. "Today I saw Buicks and Drags or Chevrolets and no Drags." Joe replied, "But I saw a car every time you did, and I saw Buicks and Chevrolets and no Fords or Buicks and no Chevrolets." If both men told the truth about what cars they saw, Drags must be what kinds of cars?

Jim is older than Dan. Four years ago Dan's age was ten times the difference between the present ages of Carl and Albert. Three years ago the difference between the ages of Bill and Dan was four years. The product of the ages of Albert and Dan is one-fourth the sum of the ages of Albert and Bill less than the square of Carl's age. Five years ago the difference between the ages of Bill and Albert was two years greater than the difference between the ages of Carl and Dan. Bill is either one year older or four years younger than Jim, who is younger than Carl. The sum of the ages of Albert and Dan is greater than the sum of the ages of Bill and Carl. How old are Jim, Bill, Albert, Dan and Carl?

ANSWERS TO PROBLEMS IN DECEMBER ISSUE

Elmer is 52 years old. Since he is thirteen times as old as Matilda was when Elmer was as old as Matilda is now, Matilda can be none other than twenty-eight years old.

Those of you who expect an answer to the problem concerning the bullet which was fired from an airplane may be disappointed to learn that no one has been able to arrive at a satisfactory solution. Of course, there can be no numerical solution because the constant of proportionality must remain an unknown. The real problem lies in solving two simultaneous nonlinear differential equations. Keep working on it; surely someone can find the solution.

And now for the coconut problem! Many students spent many hours in trying to arrive at a solution; but only one, Carl C. Jorgensen, a junior attending McKinley High School, submitted a correct answer. Following is his personal account of his method of solution:

"It is obvious that the fifth man had to deal with a multiple of five plus one; but, the fourth man had to deal with five-fourths of the fifth man's number. Therefore, we must find a whole number, divisible by four, which is a multiple of five plus one. The first such number is 16. But the number 5/4 times 16 plus 1 (21) is not divisible by 4. We must add to 16 a number divisible by 4 and a multiple of 5. The nearest such number is 20. After I had added 20 to the last number two separate times, I noted that the fourth man's number increased by 25 each time. So I found the multiple of 25, 75, that would make the number 21 plus 75 divisible by 4. By multiplying the fifth man's difference, 20, by a factor of 3, I kept the relationship correct.

"I had to add to 96 a multiple of 25, which was divisible by 4. Such a number is 100. I increased 76 proportionately. By using this method, I obtained the answer of 3,121."

Congratulations, Carl. Are you planning to enter the field of engineering by any chance? Your method of approach is wonderful.

MAGNETIC RECORDING

(Continued from page 24)

machine to "remember" the result of one operation while another is being computed. In some computers this operation is performed by punching paper tape, which then holds the signal until it is required. In some other computers an electrical delay line has the signal impressed at one end and provides storage for the time necessary for the signal to traverse the line. As opposed to delay-line storage, it offers unlimited storage time and a storage capacity determined only by the length of the recording loop used. Therefore, electrical computers of the future will probably depend on the magnetic-recording delay method.

Only a few of the many applications of magnetic recording have been outlined in this article, and these have evolved as solutions to specific problems. It can be safely predicted that, as engineers acquire a greater familiarity with this new recording technique, magnetic recording will be applied in many ways other than those which have been described.

Much virgin territory remains to be explored and mapped in the field of magnetic recording. Those who elect to pursue this relatively uncharted course should find the discoveries both challenging and rewarding.

If this paper serves its purpose in enlisting new converts, they will find a wealth of library material at hand to further enlighten their interest. Magnetic recording has come a long way, but its future appears limited only by the imagination and creation of young engineers.

ALUMVIEWS

ALUMNAE NOTES

Mrs. Catherine H. Tolson (B.S. in Architecture '25, Mortar Board, Sphinx) is employed as a Construction Management Engineer for the Office of Chief Engineer of the Army. She is now working in the U.S. Air Force Project Division of the Office, designing runways, hangars, and buildings for Air Base installations.

Miss Irene M. Pistorio (B.S. in Architecture '04, Sigma Kappa) has had an interesting and varied career. She retired from the U.S. Geological Survey, where she had worked in scientific illustrating. Miss Pistorio was active in the Engineering Alumni Association and is a life member of the Association. She was President of Columbian Women, a patriotic group, a member of other civic and patriotic groups. Among her other accomplishments, she was the first initiate of the Zeta Chapter of Sigma Kappa, won the 1900 Veerhoff Gold Medal, and was the first woman to graduate with a B.S. in Architecture. She also taught drafting for several years.

Mrs. Beverly J. Harmon (BSE. '53) is working with computers as a Scientific Programmer at the Bureau of Aeronautics, Navy Department. She and her husband, William J. Harman (BME '53) graduated together; he also works at the Bureau of Aeronautics on special purpose landing equipment. Mr. and Mrs. Harmon enjoy golf, tennis, and piano.

Miss Katherine S. Love (MS in Chemistry '25) works at the Department of Agriculture in Beltsville, Maryland. She is presently occupied with the problem of waste products utilization for fertilizer and agricultural lime. Her hobby outside of her work is travel, and she has visited Europe as well as parts of the United States, Alaska, and Mexico.

PRESIDENT'S MESSAGE

By Frank T. Mitchell
President, Engineer Alumni Association

In this special issue of *Mecheleciv* magazine, devoted to women in the field of Engineering, I should like to extend the greetings of the Engineer Alumni Association to those women who have gone out from the University to become worthy alumnae.

Several of our alumae were among those graduates of the University who enjoyed seeing Tompkins Hall of Engineering during the Open House held on March 9th. The faculty and student leaders who acted as hosts did an admirable job welcoming the many graduates who attended the Open House. Our thanks to one and all.

As President of the Association, I should like to remind each graduate of the School of Engineering that these are the concluding days for the 1957 Alumni Fund, which, as you know, is this year featuring the Tompkins Hall Equipment Fund. Nearly 100 graduates of our school have been working on the personal solicitation phase of the campaign and their efforts have been apparent in the results. Now it is up to each of us to insure the success of this important campaign by making our contribution to the Tompkins Hall Equipment Fund through the 1957 Alumni Drive.

PARTNERSHIP ENGINEERING

(Continued from page 16)

Ladies Home Journal).

If you haven't previously learned to think graphically, you'll soon be taught, for nine times out of ten when you ask him a question for instance, about his work or studies, he will willingly oblige you with a little chalk-talk. He is also famous for his functional maps to a seemingly inaccessible spot in the Metropolitan Area. You'll find these neat maps with their *printed* landmarks much more satisfactory than detailed verbal directions ending with, ". . . you can't miss it."

Finally, it is often necessary to curtail or delete conversation during strategic study hours. If there are little heirs or heiresses, a certain amount of interest is added to the maneuver. As for your inclinations to converse, fleeting opportunities may present themselves when he surfaces occasionally. However, be a bit cautious if you note a lot of slide rule activity accompanied by a cloud on the brow. This could well mean an uncooperative problem and it wouldn't be the time, even if there is a pause, to break in and discuss the baby's two new teeth. In case you have to bottle too much conversation, remember that vacations handily arrive every now and then and can be used as decompression chambers.

In conclusion, then, keep your eyes on those ever unfolding horizons and enjoy the benefits incumbent in a cooperative project with the partner of your choice.

After glancing out of the window, I would like to make one more suggestion. The sun has come out and it is a beautiful afternoon, so stack the dishes while your husband piles up his books and then go for a nice, Sunday afternoon walk.

THE WOMAN ENGINEER

(Continued from page 9)

(2) The associates with whom one will be working should be considered. Peace at home, after the workday, cannot erase the effects of friction, jealousy and harsh words encountered during the day.

(3) The working environment where, at least, one-third of each day is spent should be viewed in all of its aspects. Is it conducive to learning, to working, and to study? (The engineer not interested in these should not be one.)

(4) Last, but equally important, the inherent ability and temperament of the engineer should be known to himself and treated accordingly. Is research, development, sales, testing, teaching, or some other field indicated? Government, industry, educational and research institutions — all provide equal opportunities when all parameters are plugged into the equation.

These thoughts were not introduced as new and startling ideas, indeed, they have been repeated many times over. Neither do they complete the list. They merely serve to remind one to pause and contemplate those factors which will pay off in the long haul.

How to make the most
of your engineering career
ONE OF A SERIES

go where engineers are free to do creative work

One of the things that irks engineers most, surveys show, is getting burdened with dull, routine chores. This takes the fun out of engineering, and slows you down.

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Take Boeing, for instance. Boeing frees engineers for creative assignments by hiring engineering aides and draftsmen to handle routine jobs. Boeing engineers concentrate on *engineering*.

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A I E E

I R E

A S M E

TITANIUM

(Continued from page 11)

In recent years so many advancements concerning the shaping and finishing operations of titanium and its alloys have been made that it would be impossible to even list them. As one may well imagine, the problems concerning these operations at first were not few in number; however, research continues to solve these problems as they arise.

VI. Industrial Uses of Titanium

While the processes of titanium are continually being developed, the products of the metal are also gradually increasing. Well known is the use of titainium in military aircraft; yet it will not be long until the metal will assume as important a role in industry as it now occupies in defense.

The largest application in '56 is in commercial aircraft: the Douglas DC-7 airliner has titanium firewalls and nacelles. Titanium frames and engines will ,undoubtedly, be used also in jet transport and cargo planes and in passenger helicopters. As the prices continue on the downward swing, the metal will find uses in large truck frames and in light weight passenger trains where economic importance is placed on every pound saved. The General Motors' Firebird II, an experimental model, has a titanium body, indicating some of the long range possibilities.

Titanium has made a real contribution to industry for companies annoyed by serious corrosion losses. Two of the many examples are the Minneapolis-Honeywell titanium valve and the titanium steam jet diffuser by DuPont. The titanium valve was previously made of stainless steel; in the changing t otitanium, however, the hours of service were increased from 70 to 1680, an increase of 24 times. The steam jet diffusers were originally made of cast iron; these had to be replaced every three months, while those of titanium were put into operation two and a half years ago and are still being used.

Many other applications are still in the preliminary stage. Some of these for which titanium appears to be the logical choice are: use of titanium for high speed centrifuges, marine boiler feed pumps, lightweight, corrosion resistant equipment in the food industry, and others.

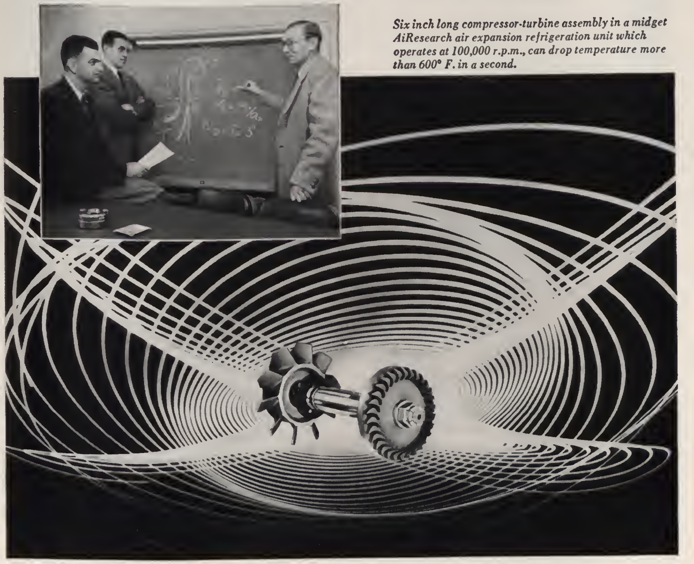
VI. Conclusion

Of the many problems concerning titanium, the cost is probably the greatest. It is the biggest hinderance to the metal. Even so, since 1948 annual commercial production of titanium sponge has increased from 9 metric tons to a planned figure for 1956 which ranges between 10,000 to 15,000 metric tons; the figure for '57 ranges between 20,000 and 52,000 metric tons. At the same time the price of the metal sponge has decreased from $5.00 to $3.00 per pound (Grade A-1 sponge), the new price decrease made in September of this year.

The high cost of the metal is not caused entirely by the high cost of the sponge; in fact, the prime factor is the cost of converting the sponge to the mill product. From the first commercial production to the present, titanium mill products have been step-children of the stainless steel industry, practically all the products of the metal having been produced in mills and on equipment principally intended for stainless steels. Also, depending on the location of mill facilities, transportation costs must be figured in the final selling price: To be completed, some mill products require the facilities of more than one mill, the unfinished products being moved around in the manner of a traveling circus. Titanium needs its own facilities capable of meeting its own special requirements —namely, a fully integrated mill combining both melting and fabrication.

Titanium already has an established place in industry due to its unusual, highly favorable, strength-weight ration and its unusual corrosion resistance. To expand its uses, however, the metal needs greater price reductions.. Although the government has been forced to take titanium under its wing, to to speak, the metal is now holding its own. Titanium is here to stay.

To the engineer who intends to blaze *new* trails...



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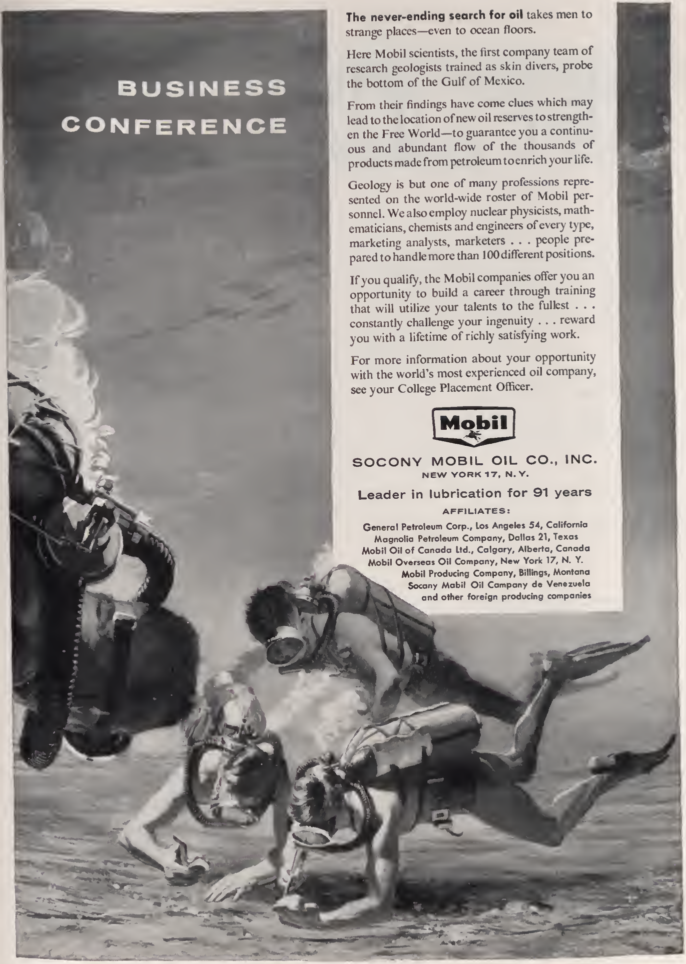
"SO YOU'RE AN ENGINEER!"

(Continued from page 12)

Sometimes I find it a distinct advantage to be a married lady engineer. The thought seems to lurk in people's minds that women go into a man's field like engineering in order to catch a husband. In fact, there was a wager on the line when I went that I would get marri d and never graduate. That gentleman had to pay off. I married all right, but I graduated in spite of it, or it might have been because of it. My sorority sisters often commented how lucky I was having "all those men" in my classes. What they didn't realize was that a large percentage were married veterans returning after World War II to complete their education. Another fair-sized percntage were serious students — the engineering curriculum is far from easy—who felt they could not afford time from their studies to date. This is exemplified by the lack of engineers who join social fraternities Of the others, many already had steady girls. I did date engineers in school, but only a few. Most of the boys I went out with, I met through my sorority sisters, eitner at fraternity socials or by direct introduction. My husband was introduced to me as a pre-med student by one of his fraternity brothers whom I already knew and who, incidentally, was an engineering student. Believe it or not, it is possible to get tired of being surrounded by men, even the exceptional ones I have at home, so I belong to several women's organizations in order to get a chance to talk to other women.

To many people I am still a novelty, but this wears off quickly with the people you work with every day. To be a woman in engineering, you should either enjoy being in the limelight occasionally or be completely oblivious to other people. At home, though, I'm just a wife and mother as any normal young woman might be —that is until something goes wrong with the television set. So far my children (ages 5, 3, and 2) don't realize that there is anything unusual happening when "Mommy" fixes it. How long can I postpone the shocking day of revelation?


BUSINESS
CONFERENCE
The never-ending search for oil takes men to strange places—even to ocean floors.
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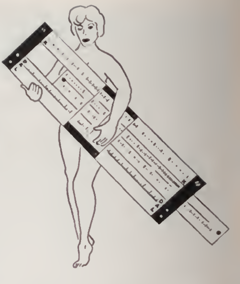
SLIPSTICK



Darling, your eyes are like deep pools of sparkling water, your lips are like rose petals wet with the morning dew, your teeth are like the finest pearls, but you have the damndest nose I've ever seen on anything except an African ant-eater.

<>

E.E.: "May I take you home? I like to take experienced girls home."
Coed: "But I'm not experienced."
E.E.: "You're not home yet, either."

<>

Impoverished C. E.: "Can you help me select a gift for a wealthy old aunt who is very weak and can hardly walk?"
Clerk: "How about some floor wax?"

<>

"How did you stop your husband from staying out late at night?" "When he came in late one night, I called out, 'Is that you, Tom?' Well, his name is Robert."

<>

All the animals came to Noah's Ark in pairs. Except the worms—they came in apples.

<>

Angry father: "What do you mean by bringing my daughter in at this hour of the morning."
C. E.: "I have to be in class at eight."

<>

Blue eyes gaze at mine—vexation
Soft hands clasped in mine—palpitation
Fair hair brushing mine—expectation
Red lips close to mine—temptation
Footsteps—Damnation

Then there was the M. E. who bought only one spur. He figured that if one side of the horse would go, the other side would have to go, too.

<>

And also there was the actress who married a director, longed for children, but didn't have any. So she divorced the director and married the producer.

<>

Sy Matthews: "Hello! Is this the city bridge department?"
Voice: "Yes, what can we do for you?"
Sy: "How many points do you get for a little slam."

<>

The latest story in inter-planetary travel circles has to do with the little Martian who made a forced landing near an air field and was promptly impounded by the Air Force. The Martian, a weird looking creature about two feet high with green skin and purple eyes, was placed under careful study by the scientists, who finally established communication with him. The Martian was brought before a panel of defense department brass for interrogation. Being obviously of superior intelligence, the little green man answered every question satisfactorily.

Finally he was asked, "How do you breed on Mars?"

The Martian looked puzzled.

"How do you reproduce your kind?" the query was reworded.

"Oh, that's simple," the little man from Mars beamed. "We have factories. One factory makes arms, another torsos, another heads and so forth — these are all shipped to an assembly plant and put together to make us. By the way how do you do it here?"

The brass proceeded to explain human love making as best they could and as their explanation reached its climax the man from Mars began to laugh hilariously.

"What are you laughing about?" he was asked.

"Ho! Ho! Ho! What do you know! On Mars that's the way we make automobiles."

<>

M.E.: "Why didn't I make a 100 on my history exam?"

Professor: "You remember the question: 'Why did the pioneers go into the wilderness.' "

M.E.: "Yeah."

Professor: "Well, your answer, while very interesting, was incorrect."

<>

Overheard at Fort Myers:

"Could I have a furlough sir? I have to help my wife with the spring cleaning."

"I don't like to refuse you, Jones, but I have a letter from your wife, and she says that you are of no earthly use around during spring cleaning."

"Sir, there are two people in this outfit who handle the truth very loosely. One of them is me. I am not married."

<>

Professor Lewellyn Rubin looked toward the next green waggled his driver confidently, and declared, "That's good for one long drive and a putt." He gave his club a mighty swing, blasted up about two inches of sod, and managed to get the ball about three feet from the tee.

The caddy stepped forward, handed him his putter, and suggested, "Now for one helluva putt."

MECH MISTER
FOR APRIL

How shall we describe Heathcliffe Aloysius Murgatroyd? (yes, that is too the way that he spells it!! But you can just call him HAM for short.) Conventionally he has the following measurements:

Height	*6 ft.*
Weight	*1 ton*
Eyes	*Green*
Hair	*None*

As for exactly for what HAM is—that's easy—he is a figment of our artist's imagination and she assures us that he can do everything. He cleans house, makes bed, sews, cooks, fixes television sets, stopped up drains and table legs. He is also highly affectionate — just like a little puppy dog, says our artist, but we have a little bit of trouble seeing the resemblance.

(Editor's note — very useful and no home is complete without one—just send your $2.00 subscription for the magazine and we will enclose one with your next copy.)